

## PERFORMANCE WORK STATEMENT

### ENGINE VIBRATION ANALYSIS COURSE 28489

#### A. PROJECT/TITLE

Engine Vibration Analysis Training for Aircraft Certification Engineers employed by the Aircraft Certification Service of the Federal Aviation Administration (FAA).

#### B. BACKGROUND

Under Title 49 of the United States Code (49 U.S.C.), the FAA is authorized to train employees as necessary in the exercise and performance of the powers and duties of the Administrator. The interests of the public, the safety of the workforce, and the credibility of the organization are best served by having qualified, proficient, and current inspectors conducting surveillance, testing, and checking functions.

#### C. SCOPE

The Contractor shall conduct one class in Engine Vibration Analysis consisting of a maximum of 12 students. Students will be FAA Certification Engineers. The course length shall provide approximately 40 hours of instruction and will accomplish the training outcomes specified below.

#### D. DEFINITIONS

Contracting Officer (CO): The person authorized to act on behalf of the Government to negotiate and award contracts and modifications thereto, and to administer contracts through completion or termination. Except for certain limited authority delegated by the Contracting Officer to a technical representative, the Contracting Officer is the only individual with the authority to direct the work of the Contractor.

Contracting Officer's Technical Representative (COTR): The authorized Government representative(s) acting within the limits of their delegated authority for management of specific projects or functional activities.

DOT: United States Department of Transportation

FAA: Federal Aviation Administration, a component agency of the U.S. Department of Transportation

Quality Assurance: Actions taken by the (Government) to ensure contractor compliance with the provisions of the Performance Work Statement.

Quality Control: Action taken by the (contractor) to ensure compliance with the provisions of the Performance Work Statement.

Training Materials: Course materials, equipment and supplies used by the Contractor in the development, presentation, practice and evaluation of training.

Training Outcomes: The total combination of skills and knowledge that the learner must acquire to perform a job assignment.

## E. APPLICABLE DOCUMENTS

Appendix A - Certification of Training and Course Evaluation. Sample attached.

## F. GENERAL REQUIREMENTS

### 1. Daily Sessions

When possible, training shall be conducted on a one-shift basis, eight hours per day. Training shall start on a Monday, end the following Friday, and may not be conducted on a federal holiday or on a weekend. Local or state holidays shall not interrupt the training period. Normal hours of training should not begin later than 9:00 a.m. Should a requirement exist to change either the hours or days of training indicated, the change must be coordinated in advance with the FAA COTR.

### 2. Student Completion Reports

Upon completion of all training, the contractor shall issue a Certificate of Training (Appendix A). The FAA student shall sign the certificate certifying the type of training provided, specific dates, and the duration of such training. One copy of each such certificate shall be submitted to the COTR.

### 3. Level of Training

FAA personnel are expected to perform at a level compatible, with the highest standards of the specialty. Accordingly, each course of instruction shall adhere to the adult learning principles, which include but are not limited to:

- a. Focus the training on "Real World" situations and applications.
- b. Emphasize how the training can be applied.
- c. Relate the training to the instructional objectives.
- d. If possible, relate the training materials to the FAA employees past experience.
- e. Allow reasonable debate and challenge of ideas.
- f. Encourage FAA employees to be resources to one another.

### 4. Training Facilities

- a. Classrooms must be large enough to accommodate at least the entire class plus one observer, with either desks or tables large enough to allow the students to be able to take notes and still have space for them to keep their reference

books open during lecture periods. Student chairs must be ergonomically appropriate for 8-hour occupancy.

b. Sufficient presentation boards for effective teaching shall be provided.

c. The classroom shall be well lighted. There shall be not less than 30 foot-candles of illumination at the student's desk or table.

d. The classroom shall be cleaned not less than two times each week of instruction.

e. Sanitary restroom facilities shall be available within convenient distance of the classroom.

f. The classroom facilities shall be adequately ventilated; heated in winter and cooled in summer. Temperature range shall not exceed 68 to 74 degrees, Fahrenheit.

g. Ambient noise shall be below the distraction point. At any position in the classroom, normal instructor voice levels should exceed the ambient noise level by 20 decibels.

h. Contractor shall comply with safety standards specified by the National Electrical Code, the National Fire Code, and the United States of America Standards Institute in conducting contract training. Each class shall receive a briefing on safety and security procedures to ensure proper egress in the event of any foreseeable emergency.

i. Local environmental distraction adversely affecting student learning shall be eliminated.

j. Adequate free student parking shall be available near the training site.

k. Visual aids used in the classroom to describe specific aircraft system or aircraft components shall be legible, visible from each student station, and color enhanced as necessary to show each system operating mode.

## 5. Qualifications

Persons utilized as instructors in this course must be professional engineers with a minimum of ten years of industry experience and three years of teaching experience. Instructors must possess at least a Bachelor of Science degree in Engineering or a related field and have a minimum of five years of experience applying vibration analysis techniques.

## 6. Training Requirements

(a) All instruction shall be presented by a qualified instructor in a classroom environment. If Computer-Based Instruction (CBI) is used to accomplish ground school training then the following requirements shall be met:

(1) Students shall receive a thorough briefing on the operation and use of the CBI equipment.

(2) At least one instructor shall be present or readily accessible by electronic means to resolve any problems or questions that the student may have regarding the material presented in the CBI program.

(3) All material presented by CBI shall be reviewed and reinforced by a

qualified instructor in classroom discussion or one-on-one with the student.

(b) In the event the FAA student fails to report for training as scheduled, or should become ill, injured or incapacitated during the training period the contractor shall promptly notify the COTR and the student's emergency contact if known.

(c) Not applicable.

(d) The contractor shall notify the COTR of the student's completion status within 5 working days after completion of the training program.

(e) Upon completion of all training, the contractor shall issue a Certificate of Training (Appendix A). The FAA student shall sign the certificate certifying the type of training provided, specific dates, and the duration of such training. One copy of each such certificate shall be submitted to the COTR.

(f) The course presentation shall include live demonstrations that will be done using basic electronic instrumentation. The classroom demonstrations will tie the theory to the practice. The instrumentation/software shall include orbit oscilloscopes, a Fast Fourier analyzer and a tracking filter, non-contact, induction and piezoelectric sensors together with some simple aids like a cantilever beam and an electric motor to simulate imbalance and other vibration features typical in piston and turbine aircraft engines. These instruments and sensors are similar to what the student is likely to encounter in field work.

(g) The contractor shall provide a course reference manual to each student. The manual shall contain information, which can be utilized in performing job functions pertaining to piston and turbine engine vibration analyses.

## G. Training Outcomes

When given oral and written questions in a classroom situation, with reference to the appropriate course training material, the students will understand:

1. Rotary and reciprocating motion as a sinusoidal wave event (wheel/spring-mass chart demonstration).
2. Basic mathematics; simple harmonic motion, sinusoidal nature of vibratory motion
3. A spring system's kinetic (KE) and potential energy (PE) storage, restoring force and motion decay illustrating internal/fluidic damping.
4. Time derivative concepts of displacement, velocity and acceleration (w/o phase) from rotary motion's sinusoidal displacement, meaning of sinusoidal sign derivative, concept of phase angle, same frame of reference connection of sinusoidal displacement differentiation to velocity; derivation from velocity to acceleration; non-connection for dissimilar frames of reference, the  $\omega$ ,  $\omega^2$  differential operators; the  $1/\omega$  and  $1/\omega^2$  integration operators, introduction to Excel software to generate engineering units corresponding to both differentiation and integration tables (in lieu of 20 century vibration slide rules).
5. The concept of phase into a rotating vector sinusoidal motion, unit of radians, amplitudes' peak-to-peak, zero-to-peak and rms concepts
6. Chart, plot of amplitude vs. a  $2\pi$  radian cycle, discuss ninety degree phase offset between displacement, velocity and acceleration, relevance to physical measurement; units radians/second, cycles/second, cycles/minute, speed's

revolution/second, revolution/minute and  $1/2\pi$  relationship between cycles/sec and radians/second: Frequency (cyc/sec) =  $1/2\pi \cdot (\sqrt{K/M} \text{ rad/sec})$ .

7. Single degree of freedom (SDOF) equation of motion (mass spring system & torsional pendulum system): Mass x acceleration =  $-Kx$ .
8. Forced single degree of freedom (SDOFF) equation of motion (mass-spring system), simple solutions to threefold systems: fixed-frame and moving-frame of reference and rotary motion/fixed-frame; discussion of Mass x acceleration +  $Kx$  = sinusoidal (alternating-force, displacement, centrifugal force); introduction to Bode and polar/Nyquist plots.
9. Charts depicting linear and non-linear relationships between displacement vs. force (for stiffness) and between velocities vs. damping.
10. Sinusoidal modeling of alternating stress, max/min peak stress, stress reversals and their relationship to mean stress.
11. The relationship between steady state mean-torque, alternating sinusoidal torque and sinusoidal torque reversal.
12. Chart/discussion of underdamped, critically damped and overdamped sinusoidal rotary motion; chart/discussion of critical damping vs. damping's logarithmic decrement and amplification factors, log-dec divergence between undamped and damped SDOF, and chart relationship of viscous and elastomeric damping domains a chart scale; relationship between critical damping and amplification factor; relationships between temperature and stiffness (Young modulus), between viscous damping and temperature.
13. The three-dimensional graphical relationship of amplitude vs. time and frequency.
14. The three-dimensional time, frequency and modulation domains.
15. Classification of vibration and acoustic signals, deterministic (periodic/non-periodic), random (stationary/non-stationary), contrast of the latter ones to transient signals.
16. Time-Frequency series analysis, relationship between time-series and complex-spectrum, signal averaging, auto-correlation, cross-correlation, Kurtosis, Cepstrum, synchronous-time-averaging, Fourier Transform, auto-spectrum, cross-spectrum, coherence, vector amplitude-phase modulation, multiple vector modulation, transfer function and superposition.
17. Summary of concepts: undamped and damped resonance, types of damping forces: viscous (emphasis on units), friction (Coulomb)/structural and fluidic; effects of viscous and structural damping on Nyquist plot, practical application of damping concept and rms amplitude in SDOF Bode plot, discussion of progressive phase relationship to resonance peak region; discussion of resonance curve sections and the influence of stiffness, damping and mass effects upon curve's slopes; superimpose SDOF equation of motion components on Bode plot resonance regions, derive phase as  $\tan^{-1}$  of the ratio of the SDOF equation components, discuss importance of phase as vectorial component parameter useful to resolve vibration problems.

## H. PERFORMANCE REQUIREMENTS FOR TRAINING COURSES

The contractor shall:

- At least two weeks prior to the course, provide each registered student with the training site address, map and/or directions to the training site, a local point of contact and telephone number, and commercially available lodging near the training site.
- Provide training that meets the training outcomes specified in G (1) - (17).
- Provide the 40 hours of training.
- Commence training upon the students' arrival at the contractor's facility on the date and time agreed upon.
- Provide a copy of the syllabus, training schedule and course description, course reference book and any other needed course materials to each student on the first training day of each training course.
- Complete the training within 5 training days barring unforeseen circumstances beyond the control of the contractor.
- Provide the COTR with a completed certificate of training signed by both the student and the contractor's instructor and the course critique (Appendix A) within 5 calendar days of the completion of the training.

## CERTIFICATE OF TRAINING - APPENDIX A

This Certificate of Training shall be prepared by the contractor and furnished to the FAA as evidence of completion of training for the student indicated.

RETURN OF AN ACCURATELY COMPLETED CERTIFICATE OF TRAINING IS ESSENTIAL SINCE CERTIFICATION FOR PAYMENT UNDER THE CONTRACT CANNOT BE MADE UNTIL THIS CERTIFICATE IS RECEIVED - - - CERTIFICATE MUST HAVE THE SIGNATURE OF THE STUDENT CERTIFYING RECEIPT OF THE TRAINING HOURS COMPLETED - -

As soon as the training has been completed, the contractor shall return this certificate together with the other items specified in the Payment Clause to the following address:

FAA Mike Monroney Aeronautical Center  
FAA Academy - ATTN: Contracts and Program Administration Branch, AMA-260  
P.O. Box 25082  
Oklahoma City, Oklahoma 73125

CONTRACTOR: \_\_\_\_\_ CONTRACT NO.: DTFA-AC- \_\_\_\_\_  
COURSE: \_\_\_\_\_ DELIVERY ORDER NO.: DTFA-AC- \_\_\_\_\_

TYPE OF FLIGHT CHECK COMPLETED (circle)		
Initial Qualification	Recurrent Qualification	Other (specify) _____

TRAINING DATES:	TOTAL TRAINING HOURS
_____	_____ Hours

COMPLETION STATUS (circle one):    PASS        FAIL        WITHDRAW        INCOMPLETE

I certify that I received the training time as reported herein.

STUDENT SIGNATURE \_\_\_\_\_ DATE \_\_\_\_\_

CONTRACTOR OFFICIAL SIGNATURE \_\_\_\_\_ DATE \_\_\_\_\_

\*\*\*\*NOTE: FAA Student: Your signature certifies that you received the training time as indicated. Payment will be made from this document. Please complete the course evaluation / course information data on pages 2 and 3.

\*\*\*\*NOTE: ANY TRAINING TIME (PER INDIVIDUAL) ABOVE AND BEYOND THAT SPECIFIED BY THE ABOVE REFERENCED CONTRACT / ORDER NUMBER REQUIRES ADVANCE APPROVAL FROM THE CONTRACTING OFFICER.



48713

# **FAA ACADEMY** **End-of-Course Evaluation**

Course: Class: Training Org: **260**

Shade circles like this: ●

Not like this: ☒

Do not write outside boxes.

The FAA Academy wants your candid opinions. Your feedback will help us provide the best possible products and services.

## Please rate the course on the following factors:

	Highly Satisfactory	Satisfactory	Somewhat Satisfactory	Slightly Satisfactory	Not At All Satisfactory	N/A
Length of course.....	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depth of information.....	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pace of training.....	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clarity of objectives.....	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Relevance to your job.....	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sequence of content.....	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Opportunity to practice.....	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Suitability of course materials.....	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Effectiveness of instructors....	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Equipment.....	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Facilities.....	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>OVERALL QUALITY.....</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

If any area needs improvement, what specific change(s) would you suggest?

Rate how well the training met your needs: ☐ Excellent ☐ Good ☐ Average ☐ Fair ☐ Poor ☐ N/A

If you selected "Fair" or "Poor," please explain.





48713

**COMMENTS:** (Please categorize any comment by printing it in the appropriate space and darkening the circle.)

☐ Suggestion

☐ Complaint

☐ Compliment

☐ Other

**REMINDER:** Did you darken the circle of each comment? **THANK YOU!**